THE REDUCTION/PREVENTION OF MUSCLE AND TENDON SPRAINS, STRAINS, AND OVEREXERTION INJURIES THRU PRE-WORK STRETCHING AND FLEXIBILITY TRAINING AT POLARIS INDUSTRIES, INC. OSCEOLA FACILITY

By

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ABSTRACT

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The purpose of this study was to present a pre-work stretching and exercise program aimed at reducing and preventing muscle and tendon sprain and strains at Polaris Industries, Inc., Osceola, Wisconsin. Risk factors have been researched in order to determine the most effective stretches and exercises to perform for optimum results.

The study addresses the problem through reduction of risk factors of muscle and tendon injures through the use of pre-work stretching and exercise aimed at increasing a person's flexibility. The review of literature indicates that a person's flexibility is a factor in the likelihood of having a muscle and tendon related injury where certain risk factors are present. The literature also reviews several cases where stretching and flexibility have been used to increase employees flexibility, reduce injury rates, and rehabilitation injured persons. The program targets specific risk factors identified in various manual material

handling positions at Polaris Industries, Osceola. Success of the program will be measured in reduced injury rates and workers compensation costs. Additional benefits could include reduced turnover and absenteeism and increase production rates.

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CHAPTER 1

STATEMENT OF THE PROBLEM

Introduction

Polaris Industries Inc. is a leader in the manufacturing of recreational vehicles, which include Polaris brand snowmobiles, all-terrain vehicles, personal watercraft, and Victory motorcycles. Polaris Industries corporate headquarters are located in Medina, Minnesota and has operations is Roseau, Minnesota, Osceola, Wisconsin, Spirit Lake, Iowa, Vermillion, South Dakota, and Winnipeg Canada with about 3800 employees.

The focus of the study is on the Osceola, Wisconsin facility. At the Osceola facility about 850 employees are employed, 700 hourly and 150 salaried. Production operations in Osceola include metal fabrication, welding, painting, seat, clutch, and engine assembly, and prototype Victory Motorcycles. Osceola is essentially a parts supplier to facilities in Roseau and Spirit Lake where full assembly of vehicles occurs, no full assembly occurs in Osceola.

Muscle sprains and strains are all too common in industry today and Polaris is no exception. Most of the work done by employees is repetitive in nature but varies with the amount of physical exertion required. Employees at Polaris are required to do a great deal of repetitive lifting, reaching, pushing, pulling and twisting which makes them susceptible to muscle sprain/strain injuries. Recent analysis of 3 years of loss statements for Polaris indicates that greater than 60% of all workers compensation costs were muscle related sprains and strains. Polaris has felt the impact of sprain and strain injuries and wants to reduce and prevent these type injuries in the future.

Muscle sprains and strain injuries can be associated with high corporate medical costs, employee turnover, absenteeism, lost productivity, and great personal suffering. In the last 3 years over $400,000 has been spent on sprain and strain related injuries at the Osceola facility. This past figure only takes into account workers compensation costs, not any of the other factors listed above, which in addition can add hundreds of thousands of dollars. It is believed that with a properly designed stretching and flexibility program, these type injuries can greatly be reduced and prevented.

Stretching and flexibility are key elements that athletes focus on for injury prevention. Employees involved in physical activity can also prevent injury. The belief is that in developing good elasticity and flexibility in our employees, the incident and severity of muscle and tendon sprains and strains will also be reduced.

Purpose of the Study

The purpose of this study was to develop a stretching and flexibility program, which would reduce the number of incidents, related to muscle sprains and strains and there associated costs.

The objectives of this study were to:

1) Conduct a risk factor analysis to determine primary risk factors.

2) Develop a stretching and flexibility program focusing on the risk factors identified as a result of the risk factor analysis.
3) Develop a system to track the effectiveness of the stretching and flexibility program.

Background and Significance

Muscle sprain and strain injuries, which include back pain and injuries, are the most common and expensive workplace injuries today. National Safety Council statistics report that 45% of all workplace injuries are muscle related sprains and strains (Simonson and Iannello, 1994). Sprains and strains are the most common type of occupationally related injuries, according to the 1997 edition of the National Safety Council's *Accident Facts*. Next to cardiovascular disease, muscle strains and sprains are the next most costly item for industry today (Claflin, 1991).

In order to gain a better understanding of the significance and loss history associated with muscle and tendon sprains and strains experienced by employees at Polaris Osceola, Jerrie Mead, Occupational Health Nurse, was interviewed.

At Polaris, Osceola, sprain and strain type injuries account for about 40% of all recorded cases, but account for about 60% of workers compensation costs. In reviewing loss history at Polaris, trends are very noticeable in a few specific departments. In the welding department, history shows the largest losses occurred from sprain and strains in the elbow and shoulders. In the press and tubing departments, the largest losses came from sprain and strain in the back and neck region. In the seat and sew department, the most frequent claims were sprain and strain of the wrist and elbow. And in the paint department, the most common injury was in the wrist and shoulder. Injuries range in type from minor muscle and tendon pulls and strains, to tendonitis and carpal tunnel syndrome, to pulled muscles in the back and slipped discs.

Ms. Mead states that, as a result of the numerous sprain and strain type injuries, many thousands of dollars of profit has been lost. Polaris Industries, Inc. is self-insured. Thus for each dollar of workers compensation paid is direct profit lost. Over the last three years, about $400,000 has been lost related to sprain and strain type injuries.

Every individual who has been involved in any type of organized athletics most likely has been taught the importance of stretching and warming up before physical activity. Professional athletes know that stretching improves their range of motion, lubricates joints, increases blood flow and warms the muscles so that when they reach the playing field, they're ready for peak performance. Industrial workers, however, seldom warm up even though their jobs may be just as demanding (Claflin, 1991).

Through a thorough evaluation of risk factors associated with manual material handling jobs at Polaris Industries, a pre-work stretching and flexibility program was developed. Through implementation of a program of this type, Polaris anticipates seeing measurable improvements in reduced injuries, productivity gains, and reduced costs associated with all.

CHAPTER TWO

Review of Literature

Introduction

Stretching has been used for years as preventative medicine in sports and athletics. The use of stretching and flexibility training is now crossing over to the industrial world as an intervention tool aimed at reducing and eliminating muscular skeletal injuries. This chapter will discuss risk factors associated with muscle injuries, the basis for how flexibility works, different types of stretching routines, benefits from stretching, and case studies where stretching has been implemented to offset muscle injuries.

Risk Factors

Several different risk factors have been associated with muscle injuries. Risk factors associated with muscle sprains and strains include inadequate or no-warm up, incorrect, inadequate or no stretching, inflexibility, weakness, strength imbalance, poor conditioning, overall fatigue, localized muscle fatigue, undernourished muscle, muscle weakness due to scarring from a previous injury, steroid injections, excess or unexpected cool-down, or inadequate muscle length (Safran, Seaber, Garrett, 1989). Several of these risk factors can be reduced and eliminated through a stretching and flexibility program.

In a study of lost-time injuries in Ontario Canada, historically the largest percentage of injuries has been sprains and strains. In 1990 there were 171,047 compensated lost-time injuries with a known nature of injury, of which 50 percent were from sprains and strains (Choi, Levitsky, Lloyd, and Stones, 1996). Analysis of 1991 workers compensation injuries at Westwood-Squibb Pharmaceuticals showed that most injuries occur during the first two hours of work (Simonson and Iannello, 1994).

Muscle sprains and strains can be prevented. Muscles are elastic and can be stretched to almost 150% of their resting length. The benefit of good elastic muscles is that long muscles develop a full range of movement. Short inelastic muscles restrict the natural range of motion (Simonson and Iannello, 1994). Short inelastic muscles do not respond to physical activity as efficiently as long flexible muscles. Thus, inelastic muscles are more susceptible to sprain and strain type injuries. Manual work of any nature requires muscular action. If the body lacks flexibility or the muscles are too weak for the work being performed, injury is likely to result.

Lack of properly warming up your muscles before physical activity puts you at greater risk of injury. Stretching can be considered a warm-up activity. Warming up your muscles has several benefits. The warm-up increases circulation and respiration, and oxygen becomes more accessible to the muscle cells and the brain, thus the individual will feel more awake and energetic. The increased blood flow increases the muscles core temperature, which reduces muscle viscosity, thus making contractions smoother and more forceful. Further more, the heating of the muscles relaxes the muscles by reducing the activity of the nerve fibers and the muscles stretch more easily (Safran, Seaber, Garrett, 1989). Stretching warms the muscle fibers, which creates less viscosity and reduces tension in the fibers reducing the risk of injury. Muscle elasticity is dependent upon blood saturation, therefore cold muscles with low blood saturation are more susceptible to injury or damage than muscles at higher temperatures and higher blood saturation. Joint range of motion is also enhanced at higher temperatures due to an increase in the extensibility of the tendons, ligament, and other connective tissues (Shellock and Pretice, 1985).

Lack of flexibility is a risk factor, which can be linked, to muscle strains and strains. It is felt that muscle tightness restricts range of motion, which in turn, puts an individual at greater risk for muscle sprain or strain. Most muscle injuries occur when the muscle when tension is at its greatest. Thus it is felt that increased flexibility will reduce muscle tension and will reduce the incidence of muscular injury (Safran, Seaber, Garrett, 1989).

Back pain and injuries can also be classified in the category as muscle injuries. For example, 80 to 90 percent of all Americans will suffer from lower back pain at some point in their life, while 60 to 80 percent of these people will find pain at work (Muir, 1994). In 1987, 34 million people in the United States suffered chronic back pain (U.S. News & World Report, 1987). It is believed that most back pain does not result from any serious musculoskeletal disorder, but from a lack of flexibility and strength (Smith, 1990).

Most daily activities performed by individuals require relativity normal amounts of flexibility. However, some athletic and industrial activities require increased flexibility for increased performance and reduced risk to injury. Activities such as gymnastics, ballet, diving, and yoga require enormous flexibility in the muscles and connective tissues. These activities often present situations where muscles are stretched beyond normal active limits. If the muscles and other tissues do not have enough elasticity to compensate for this additional stretch, it is likely that injury will occur (Shellock and Prentice, 1985). Many injuries in these types of activities are reduced through extensive and properly developed stretching programs, which target the muscles most greatly effected.

It should also be noted that injury could result from improper stretching. When looking at implementing stretching into an activity or program, whether it is a sports activity or manual material handling position, an expert should be consulted to determine the appropriate exercises for the various muscles used (Simonson and Innello, 1994).

Flexibility

Flexibility is one of the five accepted health-related components of physical fitness, the others being muscle strength, endurance, cardio-respiratory endurance, and body composition. These components of a person's physical fitness are deemed health related because an improvement in any or all of them will lead to improvements in health and well being (Stevens, 1998). An improvement in flexibility will improve a person's physical fitness level making them more able bodied to perform manual material handling jobs.

Flexibility is defined as the range of possible movement in a joints or series of joints. Several factors affect the flexibility of an individual. The factors are:

- The bone structure of the joint.
- The bulk of the muscle close to the joint.
- The normal tension of the surrounding muscles.
- The pliability of the connective tissue.
- The structure of the ligaments and tendons (Smith, 1990).

Several factors listed above can be affected and improved through stretching activities. The bone structure of the joint and the structure of ligaments and tendons are hereditary and can be changed only through reconstructive surgery. Where the ligament and tendons are attached to the bone cannot be changed through stretching. Stretching has been proven to be effective in reducing tension in muscles and increasing the pliability of ligaments and tendons.

Flexibility of one's joints is divided into two categories, static and dynamic. Static flexibility refers to the degree to which a joint may be passively moved to the end-points in the range of motion. Dynamic refers to the degree which a joint can be moved through muscle contraction. Dynamic flexibility is important in athletic performance because it is essential for an extremity to be capable of moving through a non-restricted range of motion. For example, a sprinter who cannot fully extend the knee joint in a normal stride is at a disadvantage since the stride length and his speed will be reduced. Static flexibility is important in injury prevention. There are many situations in sport where a muscle is forced to stretch its normal limits. If the muscle lacks the flexibility to compensate for the additional stretch, injury is likely to occur (Shellock and Prentice, 1985). Based upon the demands placed upon the body in both sport and industry, both can benefit from reaching maximum flexibility limits in both a dynamic and static sense.

Every muscle in the body contains various types of receptors, which, if stimulated, inform the central nervous system of what's happening with that muscle. These receptors are sensitive to changes in length of the muscle. When a muscle is stretched impulses are sent off to the central nervous system indicating that a muscle is being stretched. Impulses are then returned to the muscle, which cause the muscle contract and resist the stretch. However, if the stretch of the muscle is continuous for at least 6 seconds additional impulses are sent off causing a reflex relaxation of the muscle, before the limitations of the muscles are reached and an injury occurs. If a muscle is held in the stretched position for a period of 6 to 60 seconds, the muscle has time to relax and reach its maximum length. The stretching effect on range of motion has been shown to last up to 90 minutes (Prentice, 1982).

Types of Stretches

Stretching as defined by Webster's Dictionary is- to draw out or extend to the full length or extent. Without stretching out prior to physical activities individuals are not reaching their maximum potential and placing themselves at greater risk for injury.

There are three basic kinds of stretching, ballistic, static, and proprioceptive neuromuscular facilitation (PNF). Ballistic stretching can be described as a bouncing movement. This technique utilizes repetitive contractions of the muscle in order to produce quick stretches of the muscle. While proven to be effective, experts do not recommend this technique. The series of jerks and pulls on the resistant muscle are often greater than what the muscle can endure and injury may result. PNF techniques were first used by physical therapists for treating patients who had various types of neuromuscular paralysis. Only recently have PNF exercises been used to for increasing one's flexibility. PNF techniques all involve some combination of alternating contraction and relaxation of muscles (Shellock and Prentice 1985).

Static stretching is the most common and highly effective method used in athletics, rehabilitation, and industry. Static stretching involves stretching one's muscle to its maximal position of stretch and holding it there for an extended period of time. This technique would require you to stretch your muscle until slight discomfort, not pain, is felt. When you feel your muscle relax slightly, you are performing the technique correctly. Studies have shown that the optimum length of time to hold each stretch is from 10 to 30 seconds and can be repeated several times. Static stretching is most commonly used because it generally does not cause muscle soreness, which has been proven by physical therapist's as a effective injury rehabilitation technique, and is a simple technique an individual can perform without a partner (Shellock and Prentice, 1985).

A recent study at the Human Performance Laboratory showed that stretching for just 20 minutes three times a week can result in a 30 percent increase in range of motion (Sullivan 1993). Another study measured the effects of flexibility training over eight weeks on 24 workers employed in manual material handling operations at a hospital. Each employee performed daily stretching exercises for the wrist, forearm, shoulder, truck, knees and overall body. Prior to beginning the exercises, flexibility measurements were taken for (1) sit and reach, (2) truncal rotation, (3) lateral bending, and (4) lumbar spine extension. Measurements were taken at the beginning, four weeks, and at eight weeks into the study. The average gains in flexibility for the group were (1) sit and reach 26%, (2) truncal rotation 29%, (3) lateral bending 26%, and (4) lumbar spine 20%. Employees were also noted as saying they felt less fatigued while performing tasks throughout the day (Guo, Genaidy, Warm, Karwowski, and Hidalgo, 1992).

Benefits

It is almost universally agreed upon that stretching is key in reducing the incidence and severity of muscle injuries. Muscles that are stretched and flexible tend not to tear or pull upon sudden sharp movement or forceful exertion (Sullivan 1993).

Stretching is also believed to reduce stress. Stretching can relieve muscle tension. When muscles stay tense over a period of time, they can cut off circulation. This decreases the amount of oxygen the muscle receives and can cause a buildup of carbon dioxide and other metabolic wastes- called lactic acid- in the muscle tissues. Thus a feeling of achiness, fatigue, and tightening or knotting of the muscles, especially in the neck, shoulders, and back. Stretching helps break up these muscle knots and release the lactic acid into the blood stream where it can be transported out of the body (Sullivan 1993).

It is felt that with a properly designed stretching program one can effectively reduce back injuries and pain in addition to common muscle injuries. Many back injuries can be eliminated with increased strength in the abdominal muscle and increased flexibility in the lower back muscles and hamstrings in the legs (Smith, 1990).

Other benefits include an overall feeling of well being and good. The exercise practice of yoga is based on the idea that proper muscle movement can energize the body and mind. The belief is: “If you stretch your body, you stretch you mind” (Sullivan 1993).

The premise behind the whole idea of integrating stretching and flexibility programs in to industry is that it will 1) reduce number of muscle sprains and strains, 2) reduce workers compensation costs, 3) increase employee well being, 4) fewer lost-time injuries, 5) increase productivity and reduce costs, 6) increased employee awareness of safety to the individual and their body, and 7) reduced back injuries.

Case Studies

To determine if stretching and flexibility programs are effective at reducing injuries within an industrial environment several studies have been conducted. One study looked at a Weyerhaeuser wood mill in Cottage Grove, Oregon, which implemented a program, called Flex-N-Stretch. The glueline was the main area of concern for the facility because this was where 75% of all injuries occurred. The work was very physical with 325% turnover per year with high incidence of back injuries and carpal tunnel syndrome. The injuries associated with the position cost the company $53,963 in 1989 and $85,000 in 1988. Management felt that that many of the injuries stem from a lack of body flexibility. The workers muscles were not strong and flexible enough to perform the work. The facility developed and implemented a program called Flex-N-Stretch. Flex-N-Stretch is a series of exercises that work the entire body in a short 10-minute session. At the beginning of every shift employees performed a series of stretches, which focused on the shoulders, back, and upper leg. Since implementation:

- Turnover on the glueline has dropped from 325 to 20 percent.
- Injury rate on glueline dropped 90 percent.
- Glueline has no lost-time injuries since implementation.
- Cost of injuries dropped from $85,000 in 1988 and $53,000 in 1989 to $6,000 in the first six months of 1990 (Claflin, 1991).

At Westwood-Squibb pharmaceuticals in Buffalo, New York, management implemented a stretching program to reduce sprains and strains in its warehouse workers. Westwood began noticing a trend that most workers compensation injuries occurred within the first two hours of work. With too many injuries and complaints of muscle injuries, Westwood-Squibb elected to implement a program call “Warehouse Stretchers” aimed at reducing the incidence and severity of muscle injuries and increasing the body’s ability to accommodate the daily physical demands of working in the warehouse. Training sessions were given to the employees on the benefits of muscle condition and flexibility. Employees now perform 10 minutes of stretching exercises to increase flexibility every morning. In 1990, the company had 17 OSHA-recordable muscle injuries. In 1993 there was one OSHA-recordable muscle injury. In the three-year period implementation, average flexibility scores for the employees increased and injury incidence and severity were reduced (Simonson and Iannello, 1994).

A study was done involving firefighters to examine the effect of six months of flexibility training on the incidence and severity of joint injuries. Both flexibility and costs (lost time and medical care costs) were studied for 469 firefighters for two years beyond the intervention. The flexibility ratings of the participants were significantly better than that of non-participants. The incidence of injuries was almost the same between both groups; however, costs were significantly lower for the participants. The participants incurred about 1/3 as many lost-time expenses and had a lower per-injury cost than non-participants ($1,778 vs. $4,522) (Chenoweth, 1993).

A metal finishing company was not concerned with the monetary losses, but wanted do right by making his work force healthier. Marc LeBaron of Lincoln Plating Company didn’t set out to save $800,000, but he did. In 1993, the company's workers compensation claims hit a record $61,000. That was far below the industry average of $150,000, but LP was determined to reduce injuries no matter what the industry numbers revealed. The strategy LP chose was a mandatory stretching program. The stretching program was developed through a combination of physical therapy and nursing conferences, commonsense approaches and discussions with doctors treating LP employees for musculoskeletal disorders. Records of the company's most common MSDs provided targets for the actual exercises. Stretching was done before shifts in work groups. For about 15 minutes, employees focused sequentially on the neck, shoulders, elbows, wrists, arms, hands, fingers, waist and legs. The company developed a poster that illustrates proper technique for each move, and line coordinators lead the exercise. The coordinators were trained at the outset of the program, and the company's nurse routinely visits work groups to ensure that stretches are being performed and led properly. The first year's results were reassuring. The record high workers compensation costs dropped more than 90 percent to only $4000 in 1994. The company then entered a period of rapid growth. Workers comp costs have since risen, however they remained below the $61,000 baseline even though the workforce has expanded. Over the course of five years LP saved $800,000-$600,000 from workers compensation and $200,000 from associated medical claims (Abresch, 2001).

In the military, trainees often withdraw from basic training programs as a result of injuries sustained during training. The greatest loss of training time is attributed to overuse injuries of the lower extremities. Stretching of the hamstring muscles has been shown to reduce the number of overuse injuries in this setting. Overuse injuries have been shown to be less likely to occur if hamstring flexibility is less than 30 degrees short of neutral, with the risk increasing significantly with flexibility greater than 35 degrees short of neutral. Two groups of military trainees undergoing a 13-week basic training program were enrolled in the study. One company served as the intervention group and the other as the control group. Hamstring flexibility was measured in all trainees before and after basic training. A simple program of hamstring stretching exercises was incorporated into the trainees normal stretching routine, once daily for the control group and four times a day for the intervention group. These exercises were taught to all trainees, drill sergeants, and the company commander, and were performed with minimal supervision. Overuse injuries, defined as stress fractures, muscle strain, tendonitis, shin splints and anterior compartment syndrome, were monitored and recorded weekly for the duration of the study. Trainees in the intervention group increased their flexibility from a baseline of 41.7 to 34.7 degrees short of neutral and increase of 7 degrees, while flexibility increased by only 3 degrees in the control group. The total number of overuse injuries was also significantly lower in the intervention group, resulting in less time loss from training (Miller, 1999).

The next study focused on using stretching exercises and ergonomic education as a method to control and reduce the onset of low back pain and injuries to individuals who were at high risk of lower back pain and injuries. The individuals were recruited from different out patient practices in primary care, and partly from respondents to a local media advertisement, thus representing a group with high motivation for doing something to prevent recurrence of low back pain or injury. The individuals were divided equally into two groups, the Mensendieck group and a control group, based on critical factors to ensure true results. The Mensendieck group participated in 20 sessions of exercise and education each lasting an hour over a period of 13 weeks. The sessions covered warm-up exercises, stretching exercises, relaxation exercises, including other topics such as back anatomy and physiology, pain mechanisms, working postures, lifting techniques, and the purpose and value of the different types of exercises performed in the program. In the control group, no training or treatment was provided, however participants could seek help on their own. Data was collected at 6 months, 1 year, and 3 years after the intervention to measure effectiveness in controlling back pain and injuries. Of the Mesendieck group, 58% had recurrence of pain or injury, while the control group had 77% recurrence. The main results at the 3 year follow up showed that the Mensendieck group had a significant reduction in recurrences of low back pain and injury compared to the control group (Soukup, 2001).

Another study looked at a specific individual case to provide the effectiveness of flexibility training and injury prevention. The study looked at a 35-year-old man who had suffered from several years of back pain and injuries. The individual was a laborer whose job required much physical exertion. Doctors discovered that the man's left side of his back was weaker than his right. The individual suffered from pain in both sides due to weak muscles on the left and the muscles on the right compensating for this condition. Doctors designed a stretching program aimed at strengthening his weak areas. Within a week, noticeable improvement was shown. The man also stated he felt less pain and was less tired at the end of the day (Monsos, 1994).

Another study looked at a woman who, while at work stood up from her typewriter and experienced a sharp pain that ran down her back and leg. Examination determined her injury to be an acute herniated disc. Doctors recommended stretching exercises to help loosen tight muscles and improve the biomechanics of her back. The woman performed stretching exercises several times per day. The disc began to repair itself without major surgery. Through stretching exercises the woman's back was rehabilitated to being as good as possible for the individual (Monsos, 1994).

The final case study looked at whether an in-plant exercise program could control musculoskeletal symptoms in the neck and upper limbs of employees who worked assembly type positions in a health products plant. The assemblers in this plant faced several ergonomic risk factors which included, fine repetitive manipulation, static neck flexion, static loading of the upper limbs, contact with sharp edges, and twisted torso with extended reaches to name a few. Seventy percent of the plant hourly personnel participated in the study. Employees completed discomfort survey at four times during the day prior to beginning the study and periodically over a one-year time frame. The exercise program was designed by a physical therapist, which aimed at reducing musculoskeletal symptoms through increased blood flow, stretching, and relaxation of muscles. Plant personnel trained employees on the objectives and specifics of exercises in the program. Six volunteer employees were designated exercise leaders who lead the exercise program on a daily basis. Employees performed the exercises for seven minutes two times per shift. After 1 year of participation in the program, there were no statistically significant differences in discomfort scores or in the portion that discomfort decreased. However, at least 67% of the participants reported that the program made them feel better (Silverstein, Armstrong, Longmate, and Woody, 1988).

In the above cases, stretching and flexibility were proven to be an effective tool in reducing and eliminating injuries as well as an effective rehabilitation tool. Through a quick 10-minute a day routine, most muscle sprains and stains can be eliminated or greatly reduced.

This chapter looked at risk factors associated with muscle and tendon related injures. Most risk factors can be reduced or controlled with properly executed stretches. There are three basic kinds of stretches, ballistic, static and PNF, all of which with results can be achieved, however some have been proven to be more effective and safer than others.   A number of case studies were reviewed which analyzed situations where stretching and flexibility was used to reduce injures, strengthen weak muscles, or rehabilitate injured persons. Results of the cases studies help support the idea that pre-work stretching and flexibility training can be an effective tool in reducing muscle and tendon related injures at work.

CHAPTER THREE

METHODOLOGY

The purpose of this study is to identify and create a stretching and flexibility program at Polaris Industries Inc., Osceola facility in order to reduce and prevent muscle strains and strains. To achieve this purpose, the following objectives were established: 1) Identification of the causes and risk factors associated with muscle sprains and strains, 2) Design of the program with the intent of reducing injury, 3) Implementation of the program.

The following research methods were utilized to complete this study:

1) A review of literature was performed to analyze current information relating to muscle sprains and strains.
2) Sprain and strain risk factors were identified for common manual material handling tasks at Polaris Industries, Inc. Manual material handling jobs were evaluated to determine tasks, which pose the greatest risk for employees to suffer from a muscle or tendon sprain or strain.
3) A physical therapist was consulted to determine the best mix of stretches to increase flexibility in a person's back, abdominals, upper leg, and upper extremities.
4) Jerrie Mead, occupational nurse at the Osceola facility, was interviewed to determine the severity of the problem. A variety of tasks performed by employees were observed by the author to get a

better understanding of the hazards associated with the tasks within the facility.

The evaluation of the stretching and flexibility program is not immediately observable. To determine the effectiveness of the program, it must be implemented and utilized for a period of time. After a period of time, results can be measured and compared with before and after in areas such as:

1) Injury rates
2) Workers compensation costs
3) Productivity rates
4) Employee turnover
5) Employee absenteeism

Results in various areas should then be analyzed and appropriate changes can be made if necessary.

CHAPTER FOUR

THE STUDY

Introduction

The study will identify risk factors associated with muscle and tendon related sprains and strains common at Polaris Industries, design the program aimed at controlling or reducing sprain and strain type injuries, and develop a system to track the results of program implementation.

Risk Factors

The first objective states that risk factor analysis will be conducted to identify causes and risk factors associated with muscle sprain and strain type injuries. Common jobs, which required manual material handling, were evaluated in all departments at the Polaris Osceola facility to identify risk factors. The risk factors were evaluated based upon the most common manual material handling tasks per department. The analysis looked at the essential functions and tasks required of the position and the risk factors, which were associated with the physical demands of the task.

Work in the specific production departments varies in the amount of physical exertion and technical skill required to perform the various tasks efficiently and effectively. In all departments there is some level of manual material handling. And in each department there is a history of losses associated with muscle and tendon related sprain and strain type injuries.

Below is a matrix which gives more detail into specific tasks with associated risk factors.

Dept.	Job Title	Essential Functions	Specific Tasks	Physical Demands	Risk Factors
Press	**Operator**	1. Operation of punch press 2. Pick and place parts into shipping containers 3. Change press dies 4. Record production on log sheets 5. Maintain clean work area	• Frequent lifting and reaching at arms length to operate press • Pick and place parts from bin to press plate back to parts bin • Label parts containers	• Reaching from torso 12-24" to lift and operate controls • Bending to access parts • Crouching to place labels • Lifting of parts 1 to 8 pounds • Pushing parts carts 20-40 pounds of force • Twisting to view parts and work area • Standing for 8 hours	• Shoulder strain • Back strain / sprain • Lower extremities strain
	Coil Set-up	1. Safely remove and set up die block 2. Operate coil line equipment, feeder, straightener, uncoiler, and press 3. Correct packaging and labeling of parts	• Change out die • Use hand tools to fasten die to press • Set up new die and coil • Feed new coil • Pick and place parts from press to parts bin • Label part containers	• Climbing, crouching, reaching, bending to change die or coil • Apply force to tighten or loosen die • Lifting of parts 1 to 40 pounds • Crouching to place labels • Standing for 8 hours	• Laceration • Upper extremity sprain strain • Back stain / sprain • Lower extremities strain
Seat	**Foam Line**	1. Open mold and remove foam	• Open clamps on mold	• Reaching to open and close foam	• Back strain / sprain

		seat bun 2. Trim excess foam from bun 3. Clean mold and spray mold release 4. Secure mold lid with clamps	• Pull foam bun out of mold • Place bun in crusher • Trim excess foam with electric trimmer • Clean resin buildup from mold with scraper • Spray mold release into mold with spray bottle • Close mold and clamp shut	molds • Pulling foam buns from molds 1 to 8 #'s and placing on overhead rack to 61" • Slight bending into molds for opening, closing, pulling out parts • Hand manipulation of electric knife waist level • Squeezing spray bottle of mold release • Standing for 8 hours	• Carpal tunnel syndrome • Shoulder strain
	Assembler	1. Assemble ATV and snowmobile seats 2. Operate staple gun 3. Trim excess vinyl from seat cover 4. Place finished seat into shipping container 5. Maintain clean work area	• Place foam on plastic seat base • Place vinyl seat skin over seat base • Staple vinyl to seat base • Trim with razor excess vinyl • Pick and place seat on shipping tray • Sweep work area	• Pulling on vinyl • Hand manipulation of pneumatic staple gun • Hand manipulation of utility knife waist level • Lifting and carrying of finished seats 20-40#'s waist level • Standing for 8 hours	• Carpal tunnel syndrome • Forearm strain • Laceration • Back strain / sprain
Weld	**Seam Welder**	1. Selection of quality parts 2. Operation of seam welding equipment 3. Pick and placement of parts used in operation 4. Inspect weld	• Pick exhaust component from roller line or parts bin • Place component in seam welder and hand guide unit through welder • Use hammer to test seams	• Bending and lifting parts 4-10#'s from floor • Grasping and guiding part through welder at waist level • Arms to hammer welds	• Back strain / sprain • Elbow tendonitis • Carpal tunnel syndrome

		5. Record production	• Place part in finished goods cart	• Alternate between sit and stand	
	Spot Welder	1. Assembly of unwelded components 2. Spot weld components together 3. Inspect welds 4. Place parts in storage containers	• Reach into bin to pull parts • Insulate manifold • Spot weld seams and screen inserts • Grind and inspect welds • Place finish component in parts bin	• Bending and lifting parts 4-10#'s to and from floor • Grasping and holding part as it is pushed through welder • Hand manipulation of grinder to smooth weld • Alternate between sit and stand	• Back strain / sprain • Carpal tunnel syndrome • Elbow tendonitis
	Robot Welder	1. Accurate selection and assembly of components 2. Coordinate multiple assembly weld tasks 3. Place components into weld fixtures and cycle robot 4. Inspect welds 5. Place components into bins	• Pick and place components into weld fixture and clamp in place • Cycle welder • Pull finished parts from fixture and place in bin	• Constant opening and closing of fixture levers with hands and arms • Bending and lifting components 1-5#'s to and from floor • Reaching 12 to 24" to place parts in fixture • Standing for 8 hours	• Carpal tunnel syndrome • Back strain / sprain • Shoulder strain • Elbow tendonitis
Drive Train	**Assembler**	1. Inspect parts prior to production 2. Assemble clutches and engines 3. Inspect before packaging 4. Package parts in appropriate	• Pick various parts from containers along line and sub assemble • Place sub assembly into fixture and assemble using hand/pneumatic tools • Place parts on test stand for final inspection	• Reaching 10-24" at waist level for parts • Lifting and carrying various parts 2-25#'s at waist level • Reaching and pulling suspended pneumatic tools to various operation levels	• Hand and elbow tendonitis • Shoulder strain • Back strain / sprain

		containers 5. Maintain clean work area	• Place finished goods into/onto shipping containers • Sweep work area	• Standing for 8 hours	
Paint	**Assembler / Packager**	1. Set up collapsible shipping crates 2. Assemble exhaust components 3. Place parts and dividers in crates 4. Secure parts with banding	• Set up crate for finished units • Pick parts from crates and assemble • Place parts and dividers in various shipping containers • Secure parts in crate using banding tools	• Carrying parts 1-17#'s from container to assembly • Bending to set up shipping container • Reaching and pulling suspended pneumatic tools to various operation levels • Bending to place parts in container • Standing for 8 hours	• Back strain / sprain • Shoulder strain • Carpal tunnel syndrome
	Parts Hanger	1. Select parts hangers and place on overhead line 2. Hang parts on line 3. Remove parts from line 4. Remove hangers from line	• Pick hanger from storage rack and place on overhead rack • Pick parts from bin and place on hanger • Pick parts from line and place in bin • Pick hanger from line and place back on storage rack	• Lift, carry, and place hanger on line • Bending and lift parts 1-17#'s from container to line • Lift and carry parts to shipping container • Lift and carry hanger from line to storage rack • Standing for 8 hours	• Shoulder strain • Back strain / sprain
	Spray Painter	1. Paint parts on conveyor line with spray gun 2. Clean paint booth and guns	• Apply even coat of paint on parts as they pass through paint booth using spray gun	• Hold and sweep spray gun to apply even coat of paint on parts, sprayer 3#'s	• Shoulder strain • Back strain

		3. Maintain chemicals on washer and paint lines 4. Wear and maintain respiratory protection	• Change paper and scrap down paint in booth • Add cleaner to washer as needed • Ability to pass respirator evaluation and fit test	• Crouch and reach to spray upper and lower portions of parts • Stand for 8 hours	

In the press department employees are operating punch presses, which stamp out parts that weigh from several ounces to a few pounds. Physical requirements include bending to pick up parts and place them into the press, to stacking and moving them to storage containers and reaching, placing, and picking parts from inside the press. The previous are all manual material handling activities, which require bending, lifting, and reaching.

In the tubing department employees are operating several different types of equipment. Tasks vary from picking parts out of a container, to operating tube bending equipment, or running a drill press. All tasks are repetitive in nature and require bending and lifting and reaching to perform the requirements of most jobs.

In the welding department employees are welding exhaust systems and components. Several of the workstations in the department are robotic welders, which minimizes the static loading on operator’s muscles, however there still a large amount of manual welding of parts. In the welding process, operators are required to pick the parts, place them in a fixture, weld the parts, and move the part to the next staging area. All which are activities that require the operator to bend, lift, reach, twist, and in some workstations all with a static load on some muscles in the upper extremities.

The paint department performs painting and assembly operations. Activities include picking, placing, and removing parts on an overhead carousel, which takes parts through a paint spray booth where an operator sprays them.

Employees also assemble parts into exhaust systems in this department, which requires bending, lifting, reaching, and pulling in the upper extremities.

The seat and sew department perform operations required to assembly a seat for various machines. A CNC cutter cuts out the vinyl seat covering, then all pieces are sewn together into a seat cover in at an assembly line of sewing machines. Sewing activities require some static loading of the arms, shoulder, and back muscles. Seat covers are then assembled into a complete seat on the seat assembly line. Activities on the line include pulling, grasping, stapling, lifting, reaching, and bending.

The last department is the Drive Train department where engines and clutches are assembled. All are typical assembly line operations and activities where operators are required to pick parts and affix them to the engine or clutch. Lots of repetitive arm and hand motion using pneumatic hand tools is required while standing for eight hours a day.

Stretching Exercises

In the second objective a physical therapist was contacted to help develop the program. The physical therapist would help determine the best mix of stretching exercises which would best target the muscles with the associated risk factors discussed previously. The stretches developed focus on the major muscle groups most commonly used in the positions analyzed earlier. The following stretches target the larger more commonly used muscles of the legs, back, neck, shoulders and arms. At least two stretches, at a minimum, should be performed on each muscle group to gain the benefits discussed in chapter 2. The warm-up and stretches should continue for a minimum of ten minutes at the beginning of each shift. Before a person starts the stretching program below, they should have reviewed the chapter 2 and been through the initial training session by a qualified person.

For any program to be successful, employees must be trained on the background and significance of the program, as well as the daily requirements they will be expected to participate in. Employees should be trained on specific stretches and the muscles they are targeting, how to safely and effectively perform each stretch, and the appropriate number of repetitions and duration of each stretch. Initial training should be done by a qualified person knowledgeable physical fitness and flexibility.

Guidelines for Stretching

Stretching should not hurt. If you are doing a stretch and feel pain, discontinue the stretch. It is normal to feel a pulling sensation in the muscle, but pain is to be avoided.

Do not bounce when stretching. It is important to stretch the muscle and hold it for a few seconds. Holding the stretch longer gives the muscle time to relax rather than a bounce.

Remember the rule of opposites. Bodies were designed for a wide range of movements. Whenever repeating a motion for a period of time, gently perform a different or opposite activity to balance the body.

Stretching should not be painful when done correctly. If a person is feeling pain or has had recent physical problems, a physician should be consulted before participating in a stretching and flexibility program.

Warm-Up

Before beginning any stretches its important that a person warms up their body and gets the blood circulating in their muscles. The first three minutes of the program employees should warm up their bodies by marching in place, swinging their arms, performing jumping jacks and getting the blood circulating.

Neck Exercises

1) Lateral Neck Stretch – Tilt your head to the right, hold for 10 seconds. Then tilt your head to the left, hold for ten seconds. Avoid lifting your shoulder to your head.

2) Neck Rotation – Rotate your head to the right, hold for 10 seconds. Then rotate your head to the left for 10 seconds. Try to increase the rotation during the 10 second hold period on each side.
3) Posterior Neck Stretch – Without lifting your chin up or down, glide you head straight back into an exaggerated military attention, hold for 10 seconds.

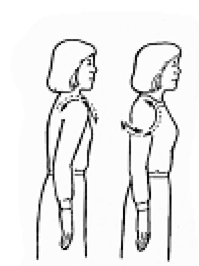
Shoulder Exercises

1) Anterior Shoulder Stretch – Stretch shoulders and arms by interlacing fingers behind your body. Slowly turn your elbows inward while straightening your arms, hold for 10 seconds

2) Horizontal Shoulder Stretch – Place right hand on left shoulder; place left hand on right elbow and pull toward left shoulder. Hold 10 seconds. Repeat with left hand on right shoulder. Hold 10 seconds.

3) Triceps Stretch – Place right hand on right shoulder. Slowly raise right elbow toward ceiling; hold 10 seconds. Place left hand on shoulder. Slowly raise left elbow toward ceiling, hold for 10 seconds.

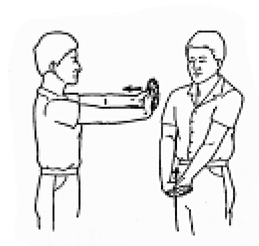
4) Shoulder Circles – Roll shoulders forward in a circular motion 5 times. Reverse and roll shoulders backward in a circular motion 5 times.



Wrist / Elbow / Forearm Exercises

1) Elbow Forearm Wrist Stretch – Straighten arms in front of you without interlacing fingers; keep palms facing toward body. Place left palm over right wrist; hold 10 seconds. Place right palm over left wrist hold for 10 seconds. Keep elbows straight.

2) Wrist Inner Elbow Stretch – Put palms together in front of chest. Slowly lower hands until you feel a mild stretch in your forearms. Hold for 10 seconds.

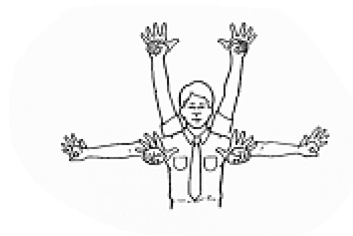


3) Forearm Massage – Gently massage right forearm muscle below elbow with pads of fingers of left hand for 10 seconds. Repeat massage of left forearm muscle for 10 seconds.
4) Wrist Forearm Stretch – Place hands together at shoulder height. Move hands toward the chest. Keep palms together. Hold for 10 seconds.
5) Wrist Circles – Hold hand in a loose fist. Gently and slowly move hand and wrist in a full circle and repeat several times. Reverse direction and repeat in several times.

Finger / Thumb Exercises

1) Thumb Stretch – With the fingers of one hand, gently stretch the thumb of the other hand away from the rest of the fingers and slightly backward. Hold for 10 seconds. Repeat with other hand.
2) Finger / Arm Stretch – Interlock fingers of both hands at shoulder height with palms facing away from the body. Keep elbows straight. Hold for 10 seconds.

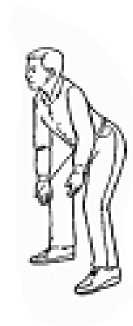
3) Hand Pumps – Make your hands into a fist, hold for 2 seconds, then open for 2 seconds. Repeat this several times. It is best to position the hands above the level of your heart for this activity.



Back Exercises

1) Low Back Stretch (Backward) – Place your hands in the small of your back. Keep your head facing toward and knees slightly bent. Gently bend backwards at the low back until you feel and easy stretch. Hold for 10 seconds.

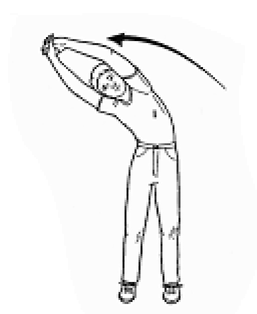
2) Low Back Stretch (Forward) – Bend your knees slightly. Place your hands on your knees and support your upper body. Slowly bend your arms allowing your low back to gently stretch forward. Hold for 10 seconds. Use your arms to push yourself upright.



3) Shoulder Blade Squeeze – Bring both arms behind back elbows straight with palms forward. Gently pull both shoulders back. Bring shoulder blades closer together. Hold for 10 seconds.

Torso and Chest Exercises

1) Side Stretch – Reach overhead, grab one wrist with the other hand, or clasp hands. You can also perform with arms at your side or in the sitting position. Slowly lean to one side until you feel an easy stretch. Hold for 10 seconds and repeat to the other side.



2) Chest Stretch – Stand facing a corner with hands on walls at should height. Shift weight forward until you feel a gentle stretch across the chest. Hold for 10 seconds and repeat.

Leg Exercises

1) Hamstring Stretch – Place 1 leg straight on an elevated surface. Keep your head up and lower back arched. Lean forward until you feel a gentle stretch.

2) Thigh Stretch – Grab your ankle. Point your knee towards the ground. Gently pull the leg back to increase the stretch. Hold for several seconds. Repeat for both legs.
3) Calf Stretch – Stand a few feet from the wall or other support. Place one foot forward and keep the leg bent. Keep the other leg straight and the heel on the ground. Slowly bend your arms. Lean your body towards the wall until you feel a gentle stretch. Repeat with both legs.
4) Groin Stretch – Hold your hands on your hips. Squat to the middle, lean to the right keeping your back straight. Hold for 10 seconds and repeat on the opposite leg.

Measurement

The last objective is to develop a system with which results of the program can be measured. The aim of the program is the reduction / prevention of muscle and tendon sprains, strains and overexertion injuries through pre-work stretching and flexibility training at Polaris Industries. This reduction of injures and better preparing employee for work can impact various areas of the company from employee job satisfaction all the way to the bottom line.

An area where effectiveness of the program can be measured is in facility injury numbers, incident, frequency, and severity rates. If the program is effective in reducing the severity and frequency of muscle and tendon sprain and strains as intended, the associated incident, frequency, and severity rates should decline. Rates can be compared prior to program implementation versus rates at 3, 6, 12, and 24-month intervals after implementation to determine impact on injury rates.

Another measure to evaluate effectiveness is workers compensation. When employees are injured at work, medical and indemnity costs are paid by the employer. Fewer work related injures should result in less worker's compensation paid out and increased profits for the employer. Dollar's of work comp should be compared on annual basis prior to program implementation versus after annually. Additional measures should include average cost of comp per employee annually and the average cost per muscle strain or sprain type injury. All are measure's which would decline with an effective pre-work stretching and exercise program.

One of the premises behind stretching is to better prepare a person to perform work more easily and efficiently by preparing muscles groups to perform. A natural area to measure effectiveness of the program would be production rates. Production rates could be compared prior to program implementation versus after to see if gains were made in productivity. This will not be an effective measure if equipment utilized in the process limits employees production capability.

Employee turnover and absenteeism can be associated with employee's dissatisfaction or ability to perform required tasks or jobs. Turnover and absenteeism rates can be compared prior to implementation versus after to see if there is a correlation between employee job satisfaction and their ability to effectively perform their work and the implementation of the pre-work stretching and flexibility program.

In summary, the program is based upon risk factor associated with common production positions at Polaris Industries in Osceola. The stretches in the program focus on increasing flexibility in the more commonly used muscles of the legs, back, neck, shoulders and arms. Through participation in the program, reduction of injury rates and workers compensation cost should be seen. Additional results of a successful program could include increased production and reduced turnover and absenteeism.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study is to develop a pre-work stretching and exercise program to reduce sprain and strain type injuries throughout Polaris, Osceola facility manufacturing operations. The objectives of the study were to:

1. Conduct a risk factor analysis to determine primary risk factors.
2. Develop a stretching and flexibility program focusing on the risk factors identified as a result of the risk factor analysis.
3. Develop a system to track the effectiveness of the stretching and flexibility program.

The aim of stretching and exercise program presented in chapter four looked at a wide variety of manufacturing operations. The program developed does not focus on a specific task, but focuses on a variety of tasks throughout the day an employee might perform and that an individual bodies major muscle groups should all be stretched, flexible, and ready to better perform the task required of their position.

A Risk Factor analysis was conducted for common material handling tasks in each department, which identified essential functions of the position and the associated risk factors associated to muscle and tendon injuries. The risk factors were then reviewed by a Physical Therapist who recommended a series of stretches, which focused on the major muscle groups of the legs, back, neck, shoulders, and arms.

The study identified risk factors associated with many manual material handling jobs within the facility. Much of the manual material handling requires bending, lifting, reaching, twisting, crouching, and standing, which puts a person at risk for a muscle or tendon related injury. The pre-work stretching exercises developed in the program focus on preparing an employees muscle for these types of activities, which reduces the risk factor for muscle and tendon injury and the chance of injury.

Conclusions

It is believed that if the program outlined in chapter four is implemented and enforced, Polaris Industries will be successful in reducing overall loses associated with sprain and strain injuries. As employees participate in the program, flexibility and range of motion will increase reducing the likelihood of injury.

Employees seem interested in participating in the pre-work stretching program. As employees see results of the program and start to feel better prepared to perform manual material handling tasks, motivation to participate should increase. In addition, having supervisors and managers participate and support the program will help maintain the program and motivation level of employees.

The stretching program will help manage the risk factors associated with manual material handling tasks at Polaris Industries, Osceola, however the risk factors are still unchanged. There will still be injuries related to manual material handling, such as muscle and tendon sprains and strains, however rates of injury should be less than pre-stretching program implementation.

Recommendations

To further reduce the risk of muscle and tendon injures further, additional workstation changes will need to be completed. Additional changes to manufacturing processes need to be evaluated and implemented. Until all manual material handling positions are eliminated, employees will physically have to bend, lift, and move materials, which puts them at risk for a sprain or strain type injury.

It is important to continue to monitor the results of the program and employee perception. If the desired results of the program are not being seen or are decreasing over time, changes to the program may be needed. Employee input should be taken into consideration on what stretches seem to provide the greatest results. Results should be evaluated on a department basis to determine effectiveness at the department level. If greater results are seen in one department over another, changes to the program need to be evaluated.

For a program of this type to be a success, it is essential that all levels of management buy in and support the program with the essential resources for it to be successful. Management must provide time for employees to participate and be an active participant to show support for the program.

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